

assume that a user touches a touch-sensitive screen with an object or a finger at position **410**, which is experienced by both sensor bar **415** and sensor bar **420**. As shown in **FIG. 4**, sensor bar **415** is oriented parallel to the X-axis **323**, which is orthogonal to the Y-axis **325**. The location of sensor bar **415** on Y-axis **325** may be represented by Y1425. Similarly, sensor bar **420** is oriented parallel to Y-axis **325**, which is orthogonal to X-axis **323**. The location of sensor bar **420** on X-axis **323** may be represented by X1430. By touching the touch sensitive screen at position **410**, which corresponds to the intersection of sensor bar **415** and sensor bar **420**, the object or the finger becomes capacitively coupled to both energized sensor bars, producing a response signal **435** on lead line **445** and a response signal **440** on lead line **450**. Both signals are provided to the control circuit **130** (**FIG. 1**), where they are received and processed by the control circuit **130**.

[0037] It should be appreciated that only one response signal from each layer is shown for simplicity of illustration. In actual operation, a touch may produce signals of various strengths on multiple sensor bars of a single sensor layer. The control circuit may determine the touch position by taking into account the signals from multiple bars in the immediate neighborhood of the touched bars. A linear or non-linear interpolation of the multiple signals from each layer may be used to accurately determine the touch position.

[0038] **FIG. 5** is a schematic illustration of another embodiment in which the sensor bars are not rectangular as shown in **FIGS. 2 through 4**. In this embodiment, there are two sensor layers, a first layer **501** and a second layer **502**. Each row of conducting elements (e.g., element **503**) of each sensor layer includes a series of diamond-shaped patches that are connected to each other with short pieces of relatively narrow rectangles (e.g., connector **504**). One advantage of this sensor geometry is that if both sensing layers are excited simultaneously the top layer (second layer **502**) shields the bottom layer (first layer **501**) except for the deletion areas between the bars, where the bars of the first layer **501** can be capacitively coupled. In this embodiment, it is possible to have a significant amount of coupling on points on both sensor layers even when both sensor layers are excited simultaneously. It should be mentioned that the patches in the conducting elements may have shapes other than diamond. For example the patches may be hexagons or the like. The size and aspect ratios of the conductive patches may be chosen such that a typical finger would cover at least a portion of a diamond on each layer.

[0039] It may be highly desirable to minimize the area occupied on the sides of touch sensors for routing lead lines. There are several possible ways of reducing this area. For instance, the lattice touch sensor envisioned by the present invention may use sensor bars connected to lead lines only at one end. This effectively reduces the lead line routing area around the touch screen. Another example is to connect more than one bar to each lead line, and use signal-processing schemes to distinguish the touched bars. In this embodiment, each lead line is shared by an equal number of bars as the other lead lines. For example, if a lead line in a sensor layer is connected to 3 bars, the other lead lines on that sensor layer are attached to 3 bars. One of the possible methods that may be applied to determine which of the bars,

sharing the same lead line, has actually been touched is that reported in co-pending U.S. patent application Ser. No. 09/998,614.

[0040] **FIG. 6** shows an alternative embodiment of the invention that reduces the area around the sensor. A sensor layer is shown in which there are eight bars that are uniquely addressed by their individual lead lines (a discrete design). In this embodiment each sensing layer forms a discrete capacitive touch sensor, such as the one described in co-pending U.S. patent application Ser. No. 10/176,564. A discrete pattern is used in **FIG. 6** for simplicity. Other connection schemes may be used without deviating from the spirit of this particular embodiment.

[0041] The lead lines on each sensor layer are divided in two groups, each group running along a different edge of the sensor. The first group **603** is connected to Indium Tin Oxide (ITO) bars **605** on the top half of the sensor. This group of lead lines runs along the left edge and goes straight to tail connection pads. The second group **607** is connected to ITO bars **609** in the bottom half of the sensor. The lead lines of this second group **607** are connected to the opposite end of the bars **609** at the right side, and run along the right edge and then along the bottom edge of the sensor to go to their corresponding contact pads. In this embodiment, three edges of the sensor are occupied by the space required for four lead lines. This is half of the space that would have been necessary for a conventional design with eight lead lines on each side of the sensor. The saving on the lead line routing area in this embodiment may be used to minimize the overall size of the sensor, or it could be used to keep the same overall sensor size but increase the active area of the sensor.

[0042] In accordance with the invention, the coordinates are determined by finding the bars carrying the peak signal and their immediate neighbors on each layer. One of the advantages of this method is that the accuracy of the coordinates determined is neither dependent on the uniformity of the sheet resistance of the conductive bars, nor is it affected by any possible imbalances caused by the sensor circuit configuration. This eases the stringent uniformity requirement that applies in conventional capacitive touch sensors, and allows the use of less expensive transparent conductive thin films in the sensor element. In other words, if the sensor bars are used to locate a touch in only one direction, the ratio of signal strength on each side is not important. Thus, the resistance uniformity of the sensor bars is much less important, thus simplifying the manufacturing process and reducing the cost of the touch sensor.

[0043] In addition, implementations of the present invention are not strongly affected by far field effects. Thus, another advantage of the invention is that simpler control circuits may be used that do not include the elements for countering far field effects. This further lowers the cost of manufacturing such touch screens.

We claim:

1. A touch-sensitive screen, comprising:

a touching surface;

a first sensor layer including:

a first set of capacitive sensor bars disposed in a first direction, each of the first set of capacitive sensor bars having a first end and a second end, wherein the